

# NFPA 11

## Standard for Low-, Medium-, and High-Expansion Foam

2002 Edition



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An International Codes and Standards Organization

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#### 5.2.4 Design Criteria for Foam Monitors and Handlines.

##### 5.2.4.1 Limitations.

5.2.4.1.1 Monitor nozzles shall not be considered as the primary means of protection for fixed-roof tanks over 18 m (60 ft) in diameter.

5.2.4.2.2\* The design parameters for the use of monitors and handline nozzles to protect tanks containing hydrocarbons shall be in accordance with Table 5.2.4.2.2.

5.2.4.3.2\* For liquids of a depth greater than 25.4 mm (1 in.), monitor and foam hose streams shall be limited for use with special alcohol-resistant foams listed and/or approved, for the purpose.

5.2.4.4 Design Parameters. Where monitors and handline nozzles are used to protect tanks containing flammable and combustible liquids requiring alcohol-resistant foams, the operation time shall be 65 minutes at listed application rates, unless the foam manufacturer has established, by fire test, that a shorter time can be permitted.

**Table 5.2.4.2.2 Foam Handline and Monitor Protection for Fixed-Roof Storage Tanks Containing Hydrocarbons**

Hydrocarbon Type	Minimum Application Rate		Minimum Discharge Time (min)
	L/min·m <sup>2</sup>	gpm/ft <sup>2</sup>	
Flash point between 37.8°C and 60°C (100°F and 140°F)	6.5	0.16	50
Flash point below 37.8°C (100°F) or liquids heated above their flash points	6.5	0.16	65
Crude petroleum	6.5	0.16	65

Notes:

(1) Included in this table are gasohols and unleaded gasolines containing no more than 10 percent oxygenated additives by volume. Where oxygenated additives content exceeds 10 percent by volume, protection is normally in accordance with 5.2.4.3. Certain nonalcohol-resistant foams might be suitable for use with fuels containing oxygenated additives of more than 10 percent by volume. The manufacturer should be consulted for specific listings or approvals.

(2) Flammable liquids having a boiling point of less than 37.8°C (100°F) might require higher rates of application. Suitable rates of application should be determined by test. Flammable liquids with a wide range of boiling points might develop a heat layer after prolonged burning and then can require application rates of 8.1 L/min·m<sup>2</sup> (0.2 gpm/ft<sup>2</sup>) or more.

(3) Care should be taken in applying portable foam streams to high-viscosity materials heated above 93.3°C (200°F). Good judgment should be used in applying foam to tanks containing hot oils, burning asphalts, or burning liquids that have a boiling point above the boiling point of water. Although the comparatively low water content of foams can beneficially cool such fuels at a slow rate, it can also cause violent frothing and "slop over" of the tank's contents.

#### 5.3.7 Foam Monitor Design Criteria for Seal Area Protection.

Monitors shall not be used as the primary means of floating roof seal fire extinguishment because of the difficulty of directing foam into the annular space and the possibility of sinking the roof.

A.5.2.3 The requirements provided in this section are based on extrapolations of test experience and appropriate listings and reflect the limitations known to date.

**A.10.6** The rate of concentrate consumption can be measured by timing a given displacement from the foam concentrate storage tank but only in systems where the storage tank is small enough and the test run time is long enough so that this can be accomplished with reasonable accuracy.

**A.10.6.3(2)** The rate of concentrate flow can be measured by timing a given displacement from the storage tank. Solution concentration can be measured by either refractometric or conductivity means (see Section C.2), or it can be calculated from solution and concentrate flow rates. Solution flow rates can be calculated by utilizing recorded inlet or end-of-system operating pressures or both.

**Table B.1 Storage Tank Protection Summary**

		Fixed-Roof (Cone) Tanks and Pan-Type Floating Roof Tanks	Applicable Floating Roof Tanks (Open-Top or Covered) Annular Seal Area
<b>Top Side Foam Application</b>			
Number of foam outlets required	Up to 24.4 m (80 ft) dia.	1 foam chamber	1 for each 12.2 m (40 ft) of circumference with a 304.8 mm (12 in.) high foam dam
	24.7 to 36.6 m (81 to 120 ft) dia.	2 foam chambers	1 for each 24.4 m (80 ft) of circumference with a 609.6 mm (24 in. high foam dam)
	36.9 to 42.7 m (121 to 140 ft) dia.	3 foam chambers	(See 5.3.3.1 and Section 5.4.)
	43 to 48.8 m (141 to 160 ft) dia.	4 foam chambers	
	49.1 to 54.9 m (161 to 180 ft) dia.	5 foam chambers	
	55.2 to 61 m (181 to 200 ft) dia.	6 foam chambers	
	Over 61.3 m (201 ft) dia. (See Table 5.2.4.2.1.)	1 additional for each 465 m <sup>2</sup> (5000 ft <sup>2</sup> )	Not covered by NFPA 11
Hydrocarbon application rates	4.1 L/min·m <sup>2</sup> (0.10 gpm/ft <sup>2</sup> ) of liquid surface (See Table 5.2.4.2.2.)		12.2 L/min·m <sup>2</sup> (0.30 gpm/ft <sup>2</sup> ) of annular ring area, above seal, between tank wall and foam dam (See Section 5.3.)
Polar solvent rates	See Manufacturer's Approval Report.		
Hydrocarbon discharge times			
Polar solvents	Flash point 37.8°C to 60°C (100°F to 140°F)	Type I 20 min	Type II 30 min
	Flash point below 37.8°C (100°F)	30 min	55 min
	Crude petroleum	30 min	55 min
	Type I Type II	30 min 55 min	(See Section 5.3.) Not covered by NFPA 11

**A.11.1** Flushing of the concentrate pump might be necessary at periodic intervals or following complete discharge of concentrate.

**A.11.2** Regular service contracts are recommended.

## Annex B Storage Tank Protection Summary

*This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.*

**B.1** See Table B.1.

Table B.1 *Continued*

Fixed-Roof (Cone) Tanks and Pan-Type Floating Roof Tanks		Applicable Floating Roof Tanks (Open-Top or Covered) Annular Seal Area
<b>Foam Outlets Under Floating Roof Tank Seals or Metal Secondary Seal</b>		
Number required	Not applicable	Mechanical shoe seal 1 — For each 39.6 m (130 ft) of tank circumference (no foam dam required) Tube seal—Over 152 mm (6 in.) from top of seal to top of pontoon with foam outlets under metal weather shield or secondary seal 1 — For each 18.3 m (60 ft) of tank circumference (no foam dam required) Tube seal — Less than 152 mm (6 in.) from top of seal to top of pontoon with foam outlets under metal weather shield or secondary seal 1 — For each 18.3 m (60 ft) of tank circumference [foam dam at least 305 mm (12 in.) high required] (See 5.3.5.4.)
Hydrocarbon application rates	Not applicable	Top-of-seal protection with foam dam at 12.2 L/min·m <sup>2</sup> (0.30 gpm/ft <sup>2</sup> ) of annular ring area. All below-the-seal with or without foam dam at 20.4 L/min·m <sup>2</sup> (0.50 gpm/ft <sup>2</sup> )
Discharge times	Not applicable	20 min — with foam dam or under metal weather shield or secondary seal Not covered by NFPA 11
<b>Foam Handlines and Monitors for Tank Protection</b>		
Size of tank	Monitors for tanks up to 18.3 m (60 ft) in diameter	Monitors not recommended
Hydrocarbon application rates	Hand hoselines for tanks less than 9.2 m (30 ft) in diameter and less than 6.1 m (20 ft) high (See 5.2.2.1.) 6.5 L/min·m <sup>2</sup> (0.16 gpm/ft <sup>2</sup> ) (See 5.2.2.2, 5.2.2.3, and 5.2.2.4.)	Handlines are suitable for extinguishment of rim fires in open-top floating roof tanks (See 5.3.4.) 6.5 L/min·m <sup>2</sup> (0.16 gpm/ft <sup>2</sup> ) For rim fires in open-top floating roof tanks (See 5.2.2.2, 5.2.2.3, and 5.2.2.4.)
Discharge times	Flash point below 37.8°C (100°F) Flash point 37.8°C to 60°C (100°F to 140°F) Crude oil (See 5.2.2.3.)	65 min 50 min 65 min Use same times as for open-top floating roof tank rim fires

Table B.1 *Continued*

		Applicable Floating Roof Tanks (Open-Top or Covered) Annular Seal Area	
Fixed-Roof (Cone) Tanks and Pan-Type Floating Roof Tanks			
<b>Subsurface Application Outlets</b>			
Number required	Same as table for foam chambers. See above. (See 5.2.4.1, 5.2.4.2, and 5.2.4.2.1.)		Not recommended
Hydrocarbon application rates	Minimum 4.1 L/min·m <sup>2</sup> (0.1 gpm/ft <sup>2</sup> ) of liquid surface Maximum 8.2 L/min·m <sup>2</sup> (0.2 gpm/ft <sup>2</sup> ) Foam velocity from outlet shall not exceed 3.05 m/sec (10 ft/sec) for Class IB liquids or 6.1 m/sec (20 ft/sec) for all other liquids (See 5.2.4.2 and 5.2.4.3.)		Not recommended
Discharge times	Flash point 37.8°C (100°F) to 60°C (140°F) Flash point below 37.8°C (100°F) Crude petroleum (See 5.2.4.3.)	30 min 55 min 55 min	Not recommended
Polar solvents	Not recommended		Not recommended

For SI units: 1 gpm/ft<sup>2</sup> = 40.746 L/min·m<sup>2</sup>; 1 ft = 0.305 m;  
1 ft<sup>2</sup> = 0.0929 m<sup>2</sup>; 1 in. = 25.4 mm; °C = °F - 32/1.8; 1 ft/sec = 0.305 m/sec.

## Annex C Tests for the Physical Properties of Foam

*This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.*

### C.1 Procedures for Measuring Expansion and Drainage Rates of Foams.

**C.1.1 Foam Sampling.** The object of foam sampling is to obtain a sample of foam typical of that to be applied to burning surfaces under anticipated fire conditions. Because foam properties are readily susceptible to modification through the use of improper techniques, it is extremely important that the prescribed procedures be followed.

A collector is designed chiefly to facilitate the rapid collection of foam from low-density patterns. In the interest of standardization, it is used also for all sampling, except where pressure-produced foam samples are being drawn from a line tap. A backboard is inclined at a 45-degree angle suitable for use with vertical streams falling from overhead applicators as well as horizontally directed streams. [See Figure C.1.1(a) and Figure C.1.1(b).]

The standard container is 200.67 mm (7.9 in.) deep and 99.06 mm (3.9 in.) inside diameter (1600 ml) and preferably made of 1.55-mm (1/16-in.) thick aluminum or brass. The bottom is sloped to the center where a 6.4-mm (1/4-in.) drain fitted with a 6.4-mm (1/4-in.) valve is provided to draw off the foam solution. [See Figure C.1.1(b).]

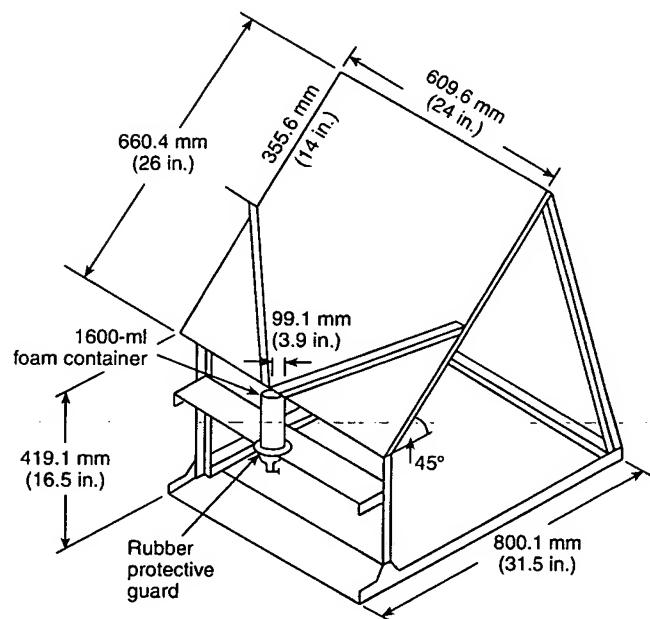


FIGURE C.1.1(a) Foam Sample Collector.

# FIRE PROTECTION HANDBOOK®

Twentieth Edition

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does gas alone. Coarse powders cause excessive surging, low flow rates, and will require larger expellant gas quantities. Fine powder will produce similar results but not to the same degree. Particle size is also responsible for the aerodynamic drag phenomenon (ADP). The momentum gained by larger particles will transport smaller particles to penetrate the updraft of a flame. Ordinarily, smaller particles would decompose or vaporize prior to penetration.<sup>3</sup> Underwriters Laboratories Inc. (UL) and Factory Mutual Research Corporation listings and ratings are based on the specified use of the particular type of dry chemical set forth by the equipment manufacturer.

### Extinguishing Properties

When introduced directly to the fire area, dry chemical causes extinction almost at once. Fire tests on flammable liquids have shown potassium bicarbonate-based dry chemical to be more effective than sodium bicarbonate-based dry chemical in extinguishment. Similarly, monoammonium phosphate has been found equal to or better than sodium bicarbonate in extinguishment effectiveness.<sup>4</sup> The effectiveness of potassium chloride is about equivalent to that of potassium bicarbonate, and urea-potassium bicarbonate exhibits the greatest effectiveness of all the dry chemicals tested.

Smothering, cooling, and radiation shielding contribute to the extinguishing efficiency of dry chemical, but studies suggest that a chain-breaking reaction in the flame is the principal cause of extinguishment.<sup>5</sup>

**Cooling Action.** It cannot be substantiated that the cooling action of dry chemical is an important reason for its ability to promptly extinguish fires. The heat energy required to decompose dry chemicals plays an undeniable role in contributing toward their individual extinguishing abilities, but the effect, perhaps, is minor. To be effective, any dry chemical must be heat sensitive and, as such, absorb heat in order to become chemically active.<sup>6</sup>

**Radiation Shielding.** Discharge of dry chemical produces a cloud of powder between the flame and the fuel; this cloud shields the fuel from some of the heat radiated by the flame. Tests to evaluate this factor concluded that the shielding factor is of some significance.<sup>6</sup>

**Smothering Action.** For special applications, such as kitchen hood, duct, and fryer fire protection, the extinguishing mechanism for dry chemical is based on the process of saponification. Saponification is the process of chemically converting fatty acid contained in the cooking medium to soap, or foam, which accomplishes extinguishment by forming a surface coat that smothers the fire.<sup>7</sup>

The soap produced by saponification is readily broken down by exposure to heat. As a result, because dry chemicals offer a substantial cooling effect, the cooking medium will flash after a brief period of time. It is due to this lack of cooling and the resultant potential for reflashing of the cooking oil that dry chemical extinguishing agents are no longer used for the protection of commercial cooking operations. Wet

chemical extinguishing agents are currently the only agents listed for the protection of this hazard.

For many years it was widely held that regular dry chemical extinguishing properties relied primarily on the smothering action of the carbon dioxide released when sodium bicarbonate was heated by fire. The carbon dioxide does undoubtedly contribute to the effectiveness of dry chemical, as does the like volume of water vapor released when dry chemical is heated. However, tests have not supported the belief that these gases are a major factor in extinguishment.

**Chain-Breaking Reaction.** The preceding extinguishing actions, when combined, exert a minimal effect. The rapidity of extinguishment is due to the interference of the dry chemical particles with the propagation of the combustion chain reaction, which reduces the concentration of "free" radicals present within the flames. To accomplish this, the dry chemical must become thermally decomposed.

The discharge of dry chemical into the flames prevents reactive particles from coming together and continuing the combustion chain reaction. The explanation is referred to as the chain-breaking mechanism of extinguishment.<sup>8,9</sup>

When multipurpose dry chemical is discharged into burning ordinary combustibles, the decomposed monoammonium phosphate leaves a sticky residue (metaphosphoric acid) on the burning material. This residue seals glowing material from oxygen, thus helping to extinguish the fire and prevent reignition.

### USES AND LIMITATIONS OF DRY CHEMICAL SYSTEMS

Dry chemical is primarily used to extinguish flammable liquid fires. Because it is electrically nonconductive, it can also be used on flammable liquid fires involving live electrical equipment. Regular dry chemical extinguishers have been tested and found suitable for use on flammable liquid and electrical fires (Class B and C fires) by fire equipment testing laboratories.

Due to the rapidity with which dry chemical extinguishes flame, dry chemical is used on surface fires involving ordinary combustible materials (Class A fires). There are several areas in the textile industry, notably opener-picker rooms and carding rooms in cotton mills, where regular dry chemical has been used effectively. However, wherever regular dry chemical is provided for use on surface-type Class A fires, it should be supplemented by water spray for extinguishing smoldering embers or in case the fire gets beneath the surface. In some baled cotton storage areas, the tops of bales can be covered with regular dry chemical to prevent surface spread should fire break out. This preventive measure does not eliminate the need for automatic sprinkler protection in such areas. Because multipurpose dry chemical becomes sticky when heated, it is not recommended for textile card rooms or other locations where removal of the residue from fine machine parts may be difficult.

Dry chemical does not produce a lasting inert atmosphere above the surface of a flammable liquid; consequently, its